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None

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H3T

(54) **Switching power supplies**

(57) A switching power supply intermittently switches current in a primary winding L_1 of a transformer T using a bipolar transistor 1. A capacitor C_2 is charged by a voltage induced in a feedback winding L_3 of the transformer and the base-emitter path of the bipolar transistor is reverse biased by this charge voltage so as to perform high-speed switching.

The application of the reverse bias voltage is performed by a transistor Q_2 which is turned on when the emitter (grounded through a resistor R) voltage of the bipolar transistor is increased to a predetermined level. The switching period of the bipolar transistor is determined by a timing capacitor C_T which is charged to reverse bias the bipolar transistor when the latter is turned on, and is discharged when it is turned off. An auxiliary winding L_4 detects flyback energy, and the ON and OFF times of the bipolar transistor are controlled to stabilize the output voltage even if an output terminal is overloaded. Variable impedance 4 of a photocoupler also provides stabilisation in response to variation in the output voltage from the secondary winding L_2.

FIG.2

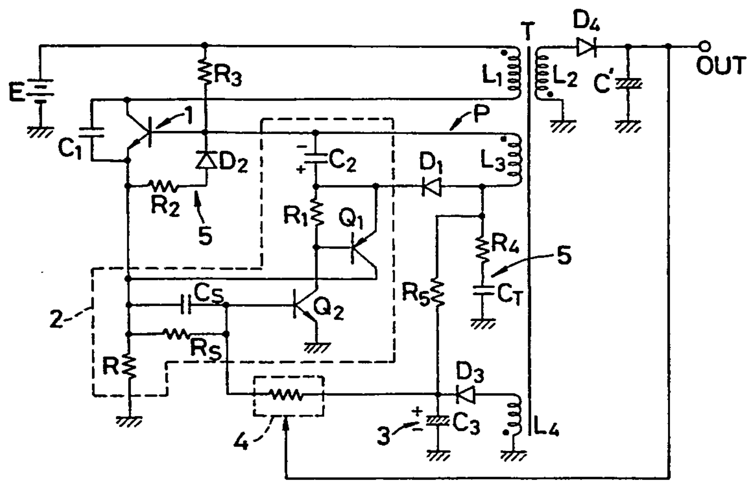

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FIG. 1

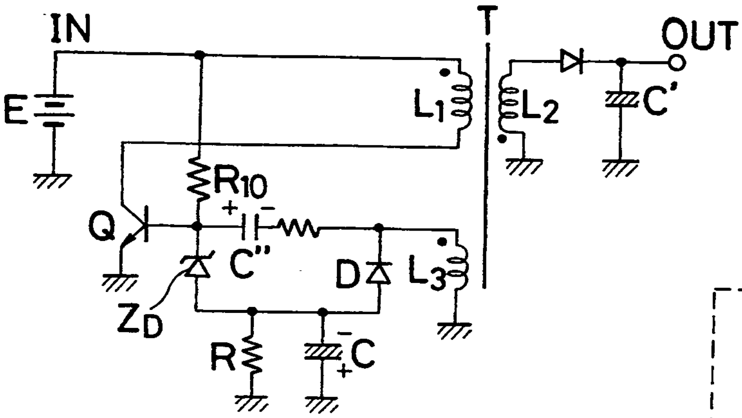


FIG. 3

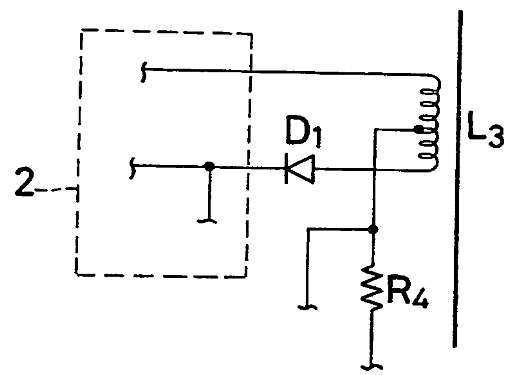
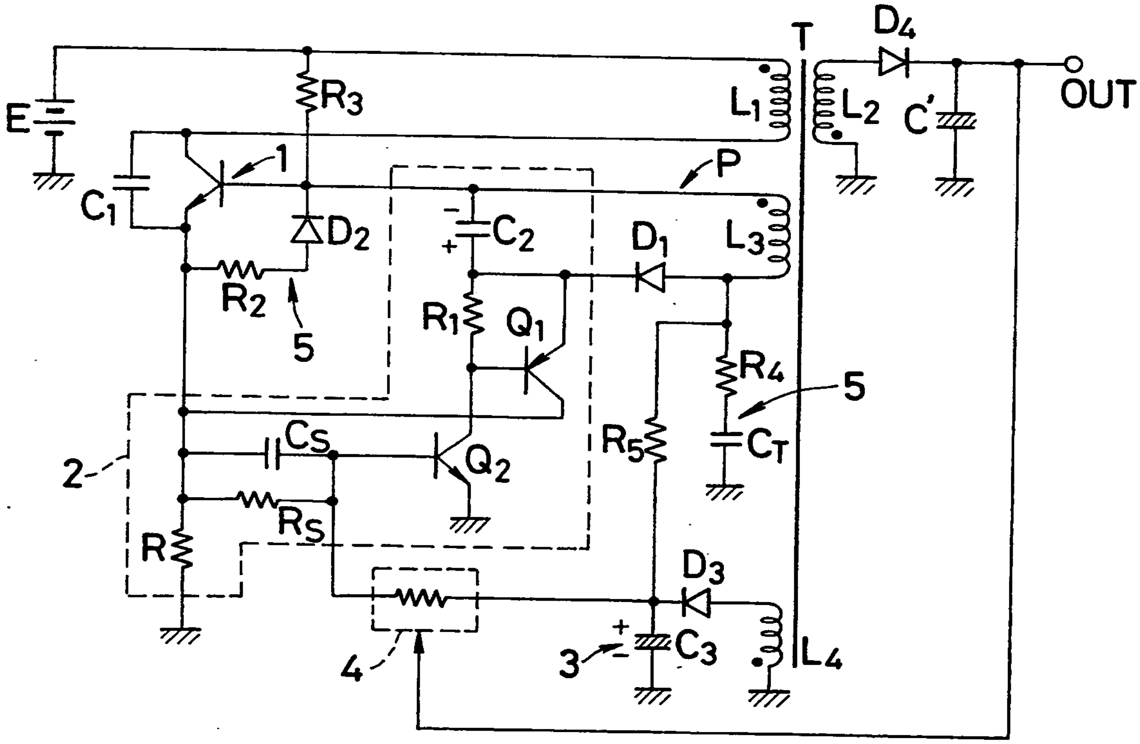


FIG. 2



SPECIFICATION

Power source circuit

The present invention relates to a power source circuit and, more particularly, to a switching power source circuit suitable as a power source of a computer or the like.

A typical conventional switching power source circuit is illustrated in Figure 1. Reference numeral T denotes a transformer. A primary winding L_1 of the transformer T receives a voltage from a power source E switched by a switching transistor Q. A voltage is rectified by a secondary winding L_2 appears at an output terminal OUT. At the beginning of operation, a current from the power source E flows in a capacitor C″ and a feedback winding L_3 through a resistor R_{10} to charge the capacitor C″. The current from the power source E also flows in the base of the switching transistor Q. A current flows in the primary winding L_1 and the collector of the switching transistor Q, thereby turning on this transistor. At the same time, a voltage is induced by the feedback winding L_3 to supply a base current to the switching transistor through the capacitor C″. In this case, the capacitor C″ is charged with polarities opposite to those illustrated in Figure 1. When the capacitor C″ is gradually charged, the base current is decreased, so that the switching transistor Q is turned off. When the switching transistor Q is turned off, a counter voltage is generated by the feedback winding L_3 to charge an electrolytic capacitor C through a diode D. When a charge voltage of the electrolytic capacitor C exceeds a predetermined voltage, a reverse bias voltage is supplied to the base of the switching transistor Q. When the switching transistor Q is turned off, a current supplied to the primary winding L_1 is cut off. A voltage will not be generated from the feedback winding L_3. As a result, the switching transistor Q is completely turned off.

When the capacitor C is discharged through a timing resistor R to release the transistor Q from the OFF state, a current flows in the base of the switching transistor Q through a starting resistor R_{10}. The above operation is then repeated. In this manner, continuous oscillation is performed to extract a continuous output at the output terminal OUT. It should be noted that a Zener diode ZD is used as a protective element for the switching transistor Q.

In the conventional power source circuit, since oscillation is performed by utilizing a signal from the feedback winding L_3, an oscillation frequency cannot be increased. The sizes of the transformer T and the electrolytic capacitor C cannot be reduced, and therefore the power source device is large and high in cost. In addition to these disadvantages, the efficiency of the device is degraded (in general, about 70%), and a load response time is long. Furthermore, when a voltage from the power source E is decreased or the output terminal OUT is lower than the predetermined voltage. A load (e.g., a computer) is adversely affected. An oscillation period of the switching transistor Q is determined by a time constant of an entire feedback circuit including an inductance of the feedback winding L_3. Therefore, the oscillation period cannot be finely adjusted, resulting in inconvenience.

It is an object of the present invention to provide a low-cost power source circuit wherein a current at a primary winding of a transformer is intermittently supplied upon a switching operation of a high-speed bipolar transistor having an emitter grounded through a current detecting resistor, and a voltage induced at a secondary winding of the transformer is rectified and smoothed to produce an output voltage, so that a compact transformer and capacitor can be used and the overall circuit becomes low in cost. The capacitor is charged by a voltage induced by a feedback winding of the transformer. When an emitter voltage of the bipolar transistor increased and the charge voltage on the capacitor reaches a predetermined level (threshold), the voltage on the capacitor is applied as a reverse bias voltage in a base-emitter path of the bipolar transistor through the transistor. Carriers left in the base of the transistor are rapidly emitted to perform high-speed switching of the bipolar transistor. The power source circuit has a period determining circuit. This period determining circuit comprises a series circuit of a diode and a resistor which is connected as a discharge path of the reverse bias capacitor between the base and emitter of the bipolar transistor. Alternatively, the period determining circuit can comprise a series circuit of a resistor and a timing capacitor which is connected between ground and the other end or a central tap of the feedback winding whose one end is connected to the base of the bipolar transistor.

In addition to the turn-off circuit for applying the reverse bias voltage to the bipolar transistor to turn it off and the period determining circuit for determining a switching period, the power source circuit also comprises a voltage correction circuit for detecting flyback energy by an auxiliary winding of the transformer to adjust the threshold of the turn-off circuit and the charge voltage of the timing capacitor so as to change an ON time of the bipolar transistor, thereby stabilizing the output voltage when a power source voltage is decreased or the output terminal is overloaded.

The power source voltage for the turn-off circuit is supplied from the feedback winding of the transformer to eliminate the need for a power source used for only the turn-off circuit, thus resulting in low cost.

Figure 1 is a circuit diagram of a conventional power source circuit;

Figure 2 is a circuit diagram showing the overall arrangement of a power source circuit according to an embodiment of the present invention; and

Figure 3 is a circuit diagram showing part of a power source circuit according to another embodiment of the present invention.

A power source circuit according to an embodiment of the present invention will be described with reference to Figure 2.

Referring to Figure 2, reference symbol T denotes a transformer which has a primary winding

L_1, a secondary winding L_2, a feedback winding L_3 and an auxiliary winding L_4. Reference numeral 1 denotes a bipolar transistor for intermittently supplying a current to the primary winding L_1 of the transformer T. The collector of the bipolar transistor 1 is connected to a power source E through the primary winding L_1, and the emitter of the transistor 1 is grounded through a resistor R. Reference symbol C_1 denotes a capacitor connected between the collector and emitter of the bipolar transistor 1. The capacitor C_1 is arranged to reduce pulse noise. Reference numeral 2 denotes a turn-off circuit which supplies a reverse bias voltage to the base of the bipolar transistor 1 when an emitter voltage thereof increases. Reference number 3 denotes a voltage correction circuit. The circuit 3 is arranged to stabilize an output voltage at an output terminal OUT in a manner to be described later. Reference numeral 4 denotes a threshold regulating circuit; and 5, a period determining circuit.

The turn-off circuit 2 comprises a transistor Q_2 for detecting an emitter voltage at the transistor 1, a transistor Q_1 which is turned on/off under the control of the transistor Q_2, a resistor R connected between the emitter of the bipolar transistor 1 and ground, a capacitor Cs and a resistor Rs which are inserted between the base of the transistor Q_2 and the emitter of the bipolar transistor 1, a capacitor C_2 one end of which is connected to the emitter of the transistor Q_1 and the other end of which is connected to the base of the bipolar transistor 1, and a resistor R_1 connected between the base and emitter of the transistor Q_1. A power source voltage P is supplied from the feedback winding L_3 through the diode D_1.

The capacitor CS is arranged to increase a frequency of positive feedback. The resistor Rs is arranged to set a positive feedback gain.

The voltage correction circuit 3 comprises the auxiliary winding L_4, a diode D_3 and a capacitor C_3. One end of the auxiliary winding L_4 is grounded, and the other end thereof is connected to the anode of the diode D_3. The capacitor C_3 is connected between the cathode of the diode D_3 and ground. The anode of the diode D_1 and the cathode of the diode D_3 are coupled through a feedback resistor R_5. The capacitor C_3 is charged by a counter electromotive force with the polarities illustrated in Figure 1 through the diode D_3. This counter electromotive force is generated by the auxiliary winding L_4. The charge voltage of the capacitor C_3 is used to control the operation of the transistor Q_2 in accordance with an impedance of the threshold regulating circuit 4.

The threshold regulating circuit 4 adjusts the level at which the transistor Q_2 of the turn-on circuit 2 is to be turned on. The threshold regulating circuit 4 is arranged such that a light-emitting element of a photocoupler is driven in response to an output voltage at the output terminal OUT so as to change an impedance of a light-receiving element connected between the base of the transistor Q2 in the turn-on circuit 2 and the cathode of the diode D_3 in the voltage correction circuit 3. In other words, the threshold of the turn-on circuit 2 is regulated by feeding back the output voltage, thereby stabilizing the output voltage. The period determining circuit 5 controls the switching period of the bipolar transistor 1. The period determining circuit 5 comprises a diode D_2, a resistor R_2, a timing capacitor C_T and a resistor R_4. The diode D_2 is connected in series with the resistor R_2. This series circuit is connected between the base and the emitter of the bipolar transistor 1 so as to protect this transistor. A resistor R_4 is connected in series with the timing capacitor C_T, and this series circuit is connected between the anode od the diode D_1 and ground. The timing capacitor is charged through the bipolar transistor 1 such that a ground side of the capacitor C_T becomes positive when the bipolar transistor 1 is turned on. When the bipolar transistor 1 is reverse biased and is turned off, the capacitor C_T is discharged. This charge/discharge operation of the capacitor C_T is repeated to determine the switching period of transistor.

It should be noted that a starting resistor R_3 is connected between the base of the bipolar transistor 1 and the power source E.

The operation of the power source circuit having the arrangement described above will be described hereinafter. A current from the power source E flows in the base of the bipolar transistor 1 through the resistor R_3. The current further flows through the feedback winding L_3, the resistor R_4 and the timing capacitor C_T to charge the timing capacitor C_T. The bipolar transistor 1 is turned on in response to the base current to energize the primary winding L_1 of the transformer T. A voltage is induced in the feedback winding L_3. This voltage is applied to the base of the bipolar transistor to increase the base voltage, thereby rapidly turning on the bipolar transistor 1.

The timing capacitor C_T is charged with a current flowing through the feedback winding L_3, the base of the bipolar transistor 1, the emitter thereof, the resistor R and ground in the order named. In this case, the ground side of the timing capacitor C_T is positively charged. A voltage corresponding to a current amplification factor is generated at the emitter of the bipolar transistor 1, and a potential difference across the resistor R is increased. The transistor Q_2 is then turned on. The impedance of the threshold regulating circuit 4 contributes to the ON operation of the transistor Q_2. At the same time, the transistor Q_1 is turned on, so that the carriers are rapidly extracted from the base of the bipolar transistor 1 due to the carriers charged by the capacitor C_2. As a result, the bipolar transistor 1 is instantaneously turned off. A current flowing through the primary winding L_1 is rapidly decreased to generate a counter voltage at the feedback winding L_3. The counter voltage charges the capacitor C_2 through the diode D_1. At the same time, the timing capacitor C_T is discharged through ground, the resistor R, the resistor R_2, the diode D_2 and the feedback winding L_3 in the order named. The bipolar transistor 1 is reverse biased through the secondary winding L_2 when the current flowing through the primary winding L_1 is rapidly decreased, so that the current is rectified and

smoothed by the diode D_4 and the capacitor C′.

Thereafter, a base current flows in the bipolar transistor 1 through the resistor R_3 to turn on the transistor 1. A current flows through the primary winding L_1. The above operation is then repeated.

The operation of the voltage correction circuit 3 will be described. This circuit serves to compensate for a voltage drop of the power source E or a voltage drop at the output terminal OUT caused by overloading. When a voltage drop occurs due to an overload, a current flowing through the auxiliary winding L_4 is increased, and a voltage across the capacitor C_3 is also increased. When the voltage across the capacitor C_3 is increased, a current flowing in the turn-off circuit 2 is increased by the threshold regulating circuit 4, and an ON time of the transistor Q_2 is shortened. As a result,the discharge time of the capacitor C_2 and hence the switching period of the bipolar transistor 1 are shortened. Energy supplied to the primary winding L.i1 is increased so as to increase the output voltage. In other words, the output voltage can be stabilized.

As has been described in detail, the bipolar transistor 1 repeats high-speed switching. The carriers left in the base of the bipolar transistor are rapidly extracted by the capacitor C_2, and the repeated frequency can be several times that of the conventional power source circuit.

The power source voltage P for the turn-off circuit 2 is supplied from the feedback winding L_3. In this case, the feedback winding L_3 may comprise a tapped feedback winding as shown in Figure 3 so as to obtain a higher voltage than that of the arrangement shown in Figure 2. The transformer T preferably comprises a magnetic circuit with a gap to avoid magnetic saturation.

According to the power source circuit of the present invention, the switching frequency can be greatly increased so as to allow the size of the transformer and the capacitor to be decreased, thereby providing a compact and low-cost power source circuit. The degradation of efficiency which is caused by an RF arrangement can be prevented. In the above embodiment, the bipolar switching transistor can be instantaneously switched to improve efficiency from 70% to 80%. In addition, heat generated from the power source circuit can also be decreased, and the switching period can be variably adjusted. Furthermore, since the load response speed can be increased and the output voltage can be stabilized, the power source circuit can be suitably used as a compact power source circuit of a computer.

CLAIMS

1. A switching power source circuit for intermittently switching a current at a primary winding of a transformer in accordance with repeated switching of a bipolar transistor so as to rectify and smooth a voltage induced at a secondary winding of said transformer, thereby obtaining an output voltage, comprising:

a period determining circuit having a resistor and a timing capacitor and connected between one end or a central tap of a feedback winding of said transformer and ground, said timing capacitor being charged with a polarity so as to reverse bias said bipolar transistor when said bipolar transistor is turned on and thereafter being discharged to run off said bipolar transistor by means of a charge voltage of said capacitor; and

a turn-off circuit for charging a capacitor by a voltage induced by said feedback winding the other end of which is connected to a base of said bipolar transistor, and for applying the charge voltage as a reverse bias voltage between the base and an emitter of said bipolar transistor through a transistor when a voltage at a resistor connected between the emitter of the bipolar transistor and ground reaches a predetermined level.

2. A switching power source circuit for intermittently switching a current at a primary winding of a transformer in accordance with repeated switching of a bipolar transistor so as to rectify and smooth a voltage induced at a secondary winding of said transformer, thereby obtaining an output voltage, comprising:

a period determining circuit having a resistor and a timing capacitor and connected between one end or a central tap of a feedback winding of said transformer and ground, said timing capacitor being charged with a polarity so as to reverse bias said bipolar transistor when said bipolar transistor is turned on and thereafter being discharged to turn off said bipolar transistor by means of a charge voltage of said capacitor;

a turn-off circuit for charging a capacitor by a voltage induced by said feedback winding the other end of which is connected to a base of said bipolar transistor, and for applying the charge voltage as a reverse bias voltage between the base and an emitter of said bipolar transistor through a transistor when a voltage at a resistor connected between the emitter of the bipolar transistor and ground reaches a predetermined level; and

a voltage correction circuit for detecting flyback energy by arranging an auxiliary winding in said transformer, correcting a threshold of said turn-off circuit and the charge voltage of said timing capacitor, and changing ON and OFF times of said bipolar transistor.

3. A circuit according to claim 1 or 2, wherein a power source voltage for said turn-off circuit is supplied from said feedback winding of said transformer.

4. A switching power source circuit substantially as hereinbefore described with reference to Figure 2 of the accompanying drawings.

5. A switching power source circuit according to Claim 4, modified substantially as hereinbefore described with reference to Figure 3 of the accompanying drawing.

6. Any novel feature or combination of features described herein.

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